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Theoretical and Experimental Studies of Questions Developed by a Study of Air Fluorescence as a Method of Detecting Nuclear Explosions

Contract Nonr 624(17)
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Technical Summary Report

Submitted to the Office of Naval Research and to
the Advanced Research Projects Agency by

The University of Pittsburgh

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Collision processes in the mesophere and thermosphere

We have been studying systematically the energy loss processes which occur in the upper atmosphere when a flux of electrons of known energy distribution is present. These studies have been conducted by means of experiments carried on sounding rockets launched into auroras and by systematic laboratory investigations.

The field studies are part of a series of rocket experiments which has been in progress for the past three years. In this time three successful flights have been achieved (actually comprising six separate auroral traversals counting up and down legs). We have data which give us the energy spectrum of electrons from 2 eV to 2000 eV, the total flux above 2 eV, and the energy deposition for primary electrons with energies greater than 5 keV. These data are available as functions of altitude from below 90 to above 160 km. We also have measured the rate of emission per unit volume of selected optical emission features. These include the (0-0) band 1NG of N_2^+ (λ3914 Å), bands of the 1PG and 2PG of N_2, the lines (^1S-^1D)λ5577, (^1D-^3P)λ6300, (^3P-^3S)λ8446, (^5P-^5S)λ7774, (^5S-^3P)λ1356, (^3S-^3P)λ1302-06 of atom oxygen and bands of the 1NG of O_2^+. We are planning this year to supplement data of this sort with a measurement of ion densities.

From these data whose quality in general is excellent we have been able to measure the effective cross sections for excitation of the various

atomic and molecular states leading to the transition enumerated. We have been able to catalogue and estimate rates of energy loss for electrons and for the quenching of metastable atomic and molecular states of oxygen and N_2. We have shown, for example, that collisons between secondary electrons and ambient "ionospheric" electrons constitute a very important, hitherto neglected, cooling process for electrons. This cooling is so effective in fact that collisions between slow electrons and atomic oxygen becomes a negligible source of green line excitation. We have demonstrated that more than 90% of green line radiation in auroras is excited during dissociative recombination of O_2^+. (This conclusion we have supported by laboratory measurements demonstrating than 20% of O_2^+ recombination excite the ^1S state of atomic oxygen.)

Laboratory Measurements

In the laboratory we have constructed apparatus which will permit us to measure cross sections for excitation of states of atomic oxygen and molecular nitrogen, to measure the radiative life-times of these states and to measure cross sections for collisional quenching of them. Within the next six months we expect to have results from measurements carried out with this apparatus.

Detection of Debris from an Explosion behind the Moon

We have investigated the feasibility of detecting a nuclear explosion behind the moon by observing a pulse of resonantly scattered solar radiation from the cloud of debris when it emerges. We have concluded that

an optical detector could be constructed which would detect debris from a device containing 500 kg or more of aluminum or 10 kg of Li in the form of ionized plus neutral debris.